The Health of Puget Sound—An Overview and Implications for Management

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Introduction

The Puget Sound Ambient Monitoring Program (PSAMP) assesses the health of Puget Sound and its resources through a number of long-term studies. The PSAMP defines five aspects of Puget Sound's health: condition of biological resources; changes in the physical environment; threats from toxic contaminants; threats from pathogens and nutrient contamination; and threats to human health. These monitoring topics were defined by review of a conceptual model of Puget Sound and the human stresses on the Sound and its resources (see Newton et al., 1998b).

This paper briefly presents some recent findings from PSAMP studies and from the work of others. In addition, for each topic, this paper also provides an example of how monitoring data have been, or will be, used to adapt efforts to manage Puget Sound and its resources.

The results presented in this paper are described in more detail in the *1998 Puget Sound Update* (Puget Sound Water Quality Action Team, 1998*)*, a coordinated, comprehensive report from the PSAMP. Presentations at this conference by a number of Puget Sound scientists offer additional details and insights into recent findings about the health of Puget Sound.

Biological Resources

The stocks and populations of many marine organisms in Puget Sound are declining or in poor condition. A 1997 review for the international Puget Sound/Georgia Basin Task Force (see West, 1998) identified 13 species of fish, seabirds, marine mammals and marine invertebrates that are declining in Puget Sound. Among the species of concern are the Olympia oyster, copper rockfish, harbor porpoise, and marbled murrelet.

Several commercially and recreationally important stocks of bottom fish are in poor condition or on the decline (Palsson et al., 1997). Some stocks of other types of fish, notably salmon and herring, are also in poor condition. The proposed listing of Puget Sound chinook and Hood Canal summer run chum as threatened species under the Endangered Species Act underscores the poor condition of fish populations in Puget Sound.

Other findings about the condition of Puget Sound biological resources are less gloomy. The population density of most diving ducks has not declined notably since 1979. Of these marine birds, only scoters and scaup showed declining numbers from 1979 through the mid-1990s (see Nysewander and Evenson, 1998). The acreage and density of kelp along the Strait of Juan de Fuca has remained fairly constant since the late 1980s (see Mumford et al., 1998). Finally, the number of harbor seals living in Puget Sound continues to increase, probably as a result of their protection under the Marine Mammal Protection Act.

Resource managers have used data from the Department of Fish and Wildlife's PSAMP surveys of marine birds to evaluate the threats posed to birds by gillnet fishing. The aerial surveys conducted over the last six years provide useful information on the relative numbers of common murres and rhinoceros auklets that might migrate into locations where gillnets for sockeye could entangle or kill the birds. Resource managers are using these long-term data and additional information from targeted aerial surveys to decide how to regulate the areas and timing of gillnet fishing to minimize entanglement threats to marine birds.

Physical Environment

The development of Puget Sound with buildings, roads, dikes, bulkheads and other structures has changed, and continues to change, Puget Sound's physical environment. One-third of Puget Sound's shoreline has been modified since the time of European settlement (see Berry et al., 1998). These changes can be very disruptive to the ecosystem because of the importance of nearshore areas in supporting sensitive life stages of many marine organisms.

Human activities may also be changing the quality of habitat in Puget Sound's marine waters. Several areas of Puget Sound appear to be susceptible to water quality degradation resulting from excess loadings of nutrients, such as fertilizers and sewage (see Newton et al., 1998a). Environmental managers are concerned that nutrients present at higher than normal levels in these areas could stimulate excess growth of phytoplankton, which could decrease oxygen concentrations in near-bottom waters, and thereby stress bottom-dwelling communities of organisms.

Despite what we seem to know about altered physical environments in Puget Sound, considerable additional information is needed to better inform us about this topic. Management of shoreline development and of nutrient loadings to Puget Sound could be much improved if time series data were better developed and if scientists could describe whether or how much change over time has occurred. Information on rates of change will help resource managers to evaluate whether existing management actions appear to be sufficient.

Toxic Contamination

A number of studies have documented the widespread distribution of toxic contaminants throughout Puget Sound. The results of these studies support previous conclusions that toxic contamination is heaviest and effects are most severe in waters of the Sound's urban areas.

PSAMP studies of the contamination of sediments and fish tissue show that toxics are primarily a concern in urban areas (see, for example, Long and Dzinbal, 1998; O'Neill et al., 1998; West and O'Neill, 1998). Using a broader set of information, the state Department of Ecology has identified 49 contaminated sediment sites (where concentrations exceed regulatory cleanup screening levels) located in urban areas, including Elliott Bay, Commencement Bay, Eagle Harbor on Bainbridge Island, Sinclair and Dyes inlets, Bellingham Bay, Everett Harbor, and Budd Inlet. PSAMP studies show that contamination of fish appears to be closely associated with areas of sediment contamination.

PSAMP data collected from the late 1980s to mid-1990s on contaminants in fish and sediment do not show any trends in concentrations over time. However, concentrations of some toxic contaminants in mussel tissue appear to have declined through the 1980s and early 1990s. For example, PCB concentrations measured in mussel tissue in the 1990s in the Duwamish River and in Elliott Bay are lower than concentrations measured in the 1970s and mid-1980s (Johnson and Davis, 1996). Mussels filter large quantities of water and the observed decrease in concentrations indicates improvement of water quality in Elliott Bay and the Duwamish River.

Information on toxic contamination of fish tissue gathered for PSAMP by the Washington Department of Fish and Wildlife led the state Department of Health and the Bremerton-Kitsap Health district in 1996 to advise people to avoid consuming rockfish from Sinclair Inlet. Data collected by Fish and Wildlife in 1995 showed that fish from Sinclair Inlet accumulated mercury to levels above 1.0 mg/kg. Standards set by the U.S. Food and Drug Administration state that mercury levels above 1.0 mg/kg make fish unsafe for human consumption.

Pathogens and Nutrients

Fecal contamination (an indicator of the potential presence of disease-causing organisms) and excessive nutrient loadings cause or threaten problems in localized areas around Puget Sound.

Fecal coliform is measured in the marine waters of shellfish growing areas to assure the safety of shellfish harvested for human consumption. The Department of Health has conducted detailed evaluations of conditions at three commercial shellfish growing areas in south Puget Sound from 1991 through 1996 (see Determan, 1998a). Conditions differ in each of these areas, but they may represent patterns that are occurring elsewhere around the Sound:

- In Burley Lagoon, all stations in an area were in compliance with applicable standards and water quality is improving or remaining steady—this may reflect the positive environmental effects of successful local efforts to find and fix pollution problems.
- In Henderson Inlet, current conditions are generally in compliance with applicable standards but concentrations are steadily increasing—this may indicate that population and development pressures could overwhelm existing water quality management efforts and that pollution control efforts should be intensified.
- In Oakland Bay, conditions at some sampling stations are not in compliance with water quality standards though conditions appear to be improving—this may reflect residual problems from localized sources that become apparent after major contaminant sources have been addressed (e.g., the partial renovation of the City of Shelton's sewage system).

Fecal coliform contamination is also measurable in the open marine waters of Puget Sound. Patterns of contamination appear to reflect the input of contamination from freshwater rivers and streams that drain the Puget Sound basin.

Degradation of Puget Sound water quality caused by excess loading of nutrients appears to be limited to semi-enclosed inlets, bays, and passages. The combination of poorly mixed marine waters and excess nutrient contributions from the watershed creates concern primarily in some areas of lower Hood Canal and the bays and inlets of south Puget Sound and the Whidbey basin (see Newton et al., 1998a).

Information on pathogens and nutrients in Puget Sound's waters are used to direct local actions along the shoreline and in watersheds to protect or restore shellfish growing areas and marine water quality. Determan's paper (1998a) in this volume details three examples of the links between water quality monitoring data and watershed management activities related to the protection or restoration of commercial shellfish growing areas.

Human Health

Three types of contamination can threaten human health in Puget Sound: toxic contamination of fish, and fecal (pathogen) and biotoxin contamination of shellfish.

The risks of eating Puget Sound seafood have not been formally evaluated with a risk assessment or health analysis. However, scientists have used the results of a risk assessment of the lower Columbia River to conclude that people consuming English sole from urban areas of Puget Sound or salmon from any Puget Sound location face an increased risk of cancer due to PCB contamination of Puget Sound fishes. The risks to humans from mercury in Puget Sound are not so clear; one of two Columbia River assessment approaches suggests that mercury concentrations observed in Puget Sound rockfish are high enough to cause adverse health effects in fish consumers.

Risks of illness from consumption of Puget Sound shellfish tainted by pathogens and biotoxins are managed by state and local health department programs to evaluate environmental quality at shellfish harvest areas.

Based on relatively high levels of fecal contamination, Washington Department of Health prohibited or restricted harvest of shellfish from many commercial shellfish growing areas in Puget Sound in the late 1980s. More recently, the commercial harvest area subject to downgrades (new prohibitions or restrictions on harvest) has been nearly balanced by upgrades in classifications for areas where water quality conditions have improved.

Local health districts and the Department of Health also evaluate conditions at recreational shellfish beaches. Evaluated beaches are classified as open or closed to recreational harvest. As of 1996, 52 of 98 Puget Sound beaches that had been evaluated were listed as open to harvest.

To protect shellfish consumers from paralytic shellfish poisoning (PSP), the Department of Health assesses biotoxin concentrations in mussels from a network of sampling locations throughout Puget Sound. As in previous years, high biotoxin concentrations from 1995 through 1997 necessitated temporary shellfish harvest closures for many parts of Puget Sound (see Determan, 1998b). Three sites—two on the Strait of Juan de Fuca and one in Quartermaster Harbor (between Vashon and Maury Islands)—had concentrations of the PSP biotoxin high enough to shut down harvest for more than 100 days through the three year period. Eight more sites had high PSP biotoxin concentrations for at least 30 days during this time. Four of these eight locations are in south Puget Sound where high PSP occurred during an atypical bloom late in the year in 1997.

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